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Insight into GIS Usage in Dangerous Area Survey

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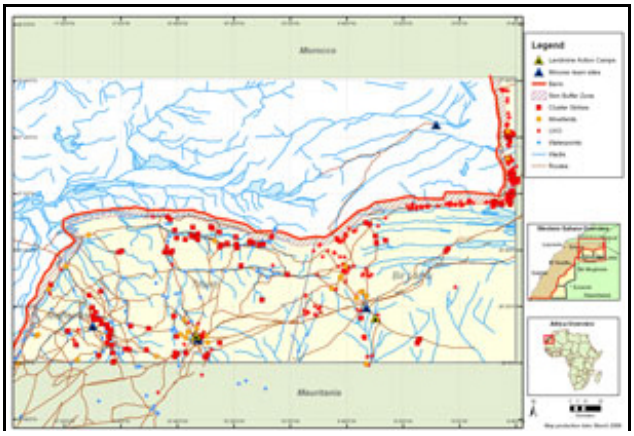
Western Sahara's 16-year conflict with Morocco caused widespread contamination from landmines and other explosive remnants of war. Landmine Action is a U.K.-based nonprofit organization that has conducted survey, marking and clearance activities in Polisario-controlled areas of Western Sahara since 2006. Its main goals are to make these areas safer for the people of Western Sahara, to reduce risks and land denial caused by contamination, and to successfully carry out humanitarian demining.

Budib Community handover in June 2008. Pictured left to right: Community Head, GIS Officer and Survey Team Leader. *Photo courtesy of the author*

During their protracted conflict with Western Sahara, Moroccan forces constructed six berms—defensive walls made of sand and rock—which were contaminated by one to two million anti-personnel and anti-tank mines.[1] The main berm is approximately 2,400 kilometers (1,491 miles) long, running diagonally north to south across the entire Western Sahara territory. The Dangerous Area Survey[2] was carried out in Polisario-controlled Western Sahara from 2006–2008, and the results are mapped in Geographic Information Systems and recorded in the Information Management System for Mine Action.

The use of GIS in mine action has gained popularity in recent years. A GIS Consultant initially set up a GIS for Western Sahara in Environmental Systems Research Institute's ArcView® software, ArcGIS®, in March 2007 to centralize data collection during the survey. Landmine Action's operational staff uses GIS in Western Sahara to record locations of mines and unexploded ordnance, and to delineate boundaries of minefields and cluster-strike areas and their associated details in the form of maps and databases. Maintaining this GIS is a challenging process that requires regular input and a systematic exchange of data between field teams and the GIS Officer. Owing to the nomadic population of Western Sahara, the threat of contamination poses a high risk, and it is therefore crucial to have detailed information on the exact locations of contamination. A well-structured and organized GIS has proven to be of paramount importance in Western Sahara.



Spatial Data Collection and Assimilation

Due to the limited availability of up-to-date maps for Western Sahara, the GIS Consultant and GIS Officer primarily collected spatial data using a Global Positioning System. These personnel obtained American and Russian topographic maps and took GPS readings of ground reference points with known coordinates to determine accuracy levels. The Russian maps proved to be more precise and were then geo-referenced. Landmine Action used GPS to build a better topographic picture of Western Sahara. This improvement helped Landmine Action and other stakeholders—such as the Polisario military and the U.N. Mission to Western Sahara (MINURSO)—gain familiarity with the geographical coverage and understand the explosive-remnants-of-war

(Click image to enlarge)
Figure 1: Dangerous Areas—Western Sahara Northern Sector. *Graphic courtesy of Landmine Action*

contamination to identify challenges associated with clearance. Data gathered by the Landmine Action field teams is mapped in the GIS and stored for subsequent retrieval and analysis, and all mapping is carried out in ArcGIS. The following are examples of collected data:

- **Point data**: The location of individual mines or ERW items, turning points and benchmarks of dangerous areas, water points, towns and airplane and helicopter landing sites. Knowing the location of landing sites is crucial in determining the closest evacuation point for casualties.
- **Polyline data**: GPS readings of *wadis*, routes and tracks are recorded. This data is essential to navigating back to the ordnance location for clearance. In the inhospitable desert conditions of the Sahara—where there are no road signs or markings to guide direction—building a network of known routes is critical, especially when responding to emergencies and accidents.
- **Polygon data**: Administrative boundaries, perimeters of minefields, cluster-strike areas, and cleared areas are vital to defining and assessing the scope of contamination and progress made, and in determining clearance requirements.

Detailed data of the dangerous items and areas, such as ordnance type, size of area, types of blockages caused by contamination, survey reports completed by field survey teams, and field sketch maps scanned as JPEGs, are hyperlinked in ArcGIS, allowing the querying and retrieval of information pertaining to a particular task to be contained in one consolidated system. To keep track of this wealth of spatial data and avoid duplication of data collection, detailed metadata is recorded for all spatial data in the form of a fully functional and searchable Microsoft Access® database.

The poor availability of spatial data in Western Sahara has been overcome by the effective use of GIS and data collection during the survey, leading to the development of digital spatial mapping. This data is collected and used by Landmine Action teams, as well as being shared with Polisario and MINURSO. MINURSO also collects data and reciprocates the information exchange with Landmine Action. The Dangerous Area Survey that Landmine Action completed in December 2008 identified a total of 195 dangerous areas consisting of 158 cluster-strike areas and 37 minefields in Western Sahara covering an area of approximately 27 square kilometers (10 square miles) and about 322 square kilometers (124 square miles) respectively. A majority of these dangerous areas are located in the northern sector, which is far more contaminated than the southern sector.

GIS Capacity Building and Training of National Staff

A Saharawi national working for Landmine Action was comprehensively trained from basic GIS to advanced mapping and analysis by a GIS Consultant. He receives regular refresher training and is provided technical support from a GIS Officer in London to further build his skills. He is fully competent in assimilating all the data collected by the field teams into the GIS and in generating highly accurate maps at short notice for the field teams. The Landmine Action field staff in Western Sahara is fully trained and proficient in the use of GPS. All GIS processes undertaken as part of the Saharawi GIS Officer's job are documented in the form of training manuals. Standard operating procedures for GIS were established by Landmine Action's GIS Officer in London to provide Landmine Action staff with guidelines for the efficient collection, collation and storage of spatial data.

Since November 2008, the GIS Officer has also taken on management of Western Sahara's Information Management System for Mine Action and is making excellent progress. IMSMA is used as a complementary tool with ArcGIS, especially for generating quick reports and for tracking the progress of survey work.

The Benefits of GIS

The use of GIS provides several benefits to mine action, including aiding clearance and decision making, identifying hotspots, providing visualization of contamination, and facilitating community handovers.

Aiding clearance and decision making. Many individual dangerous items that are identified are cleared on the spot through the use of Landmine Action's three clearance teams. However, on bigger tasks such as minefields and cluster-strike areas, Landmine Action's Operations department uses GIS for planning systematic clearance methods and determining the length of time needed for clearance based on the challenges posed by terrain and area size. Clearance activities require significant time and money; therefore, it is essential to be as efficient and targeted as possible to avoid wasting both of these valuable resources.

Identifying hotspots. Based on Landmine Action survey results, the Tifariti and Bir Lahlu regions of Western Sahara

have been identified as the most contaminated regions of the country. Landmine Action's GIS Officer in London and the Operations Department have prioritized this contamination by taking into account a range of factors such as distance from settlements, tracks and water points. Hotspots of contamination are often located within close range of the main towns and population centers.

Providing visualization of contamination. Maps provide a better understanding of the contamination situation on the ground and help staff visualize clusters of contamination in specific regions or areas. Maps also provide an excellent snapshot for donors to assess survey results and clearance progress. It is also helpful to see contamination from a geographical perspective, in order to see distance between contaminated areas and towns, roads and waterholes.

Facilitating community handovers. In February 2007, Salek, a 14-year-old Saharawi boy in Budib, died from injuries caused by a BLU63 cluster submunition that exploded in his hand. Salek was unaware of the dangers of this shiny metallic ball. One of the first clearance tasks Landmine Action carried out in Western Sahara was to free Salek's community of unexploded ordnance. The area was cleared and a community handover ceremony took place in June 2008. The community members received formal documentation of the clearance, which was accompanied by a detailed map clearly indicating the area had been cleared and was safe for use.

(Click image to enlarge)
Figure 2: Dangerous Areas—Western Sahara Southern Sector. *Graphic courtesy of Landmine Action*

Future Plans

At the moment, Landmine Action primarily uses GIS for mapping in Western Sahara. However, now that the Dangerous Area Survey is completed in Western Sahara and all the required data has been collected, Landmine Action has used GIS from a more analytical perspective to aid decisions for developing an appropriate clearance plan. Landmine Action's GIS Officer in London has utilized techniques such as proximity and buffer analysis to rank clearance tasks as high, medium and low priority, taking into account their distance from settlements, water points and frequently used tracks. Further analysis can be done by using a weighting system that can be assigned to factors such as the type of munition and existing markings in the contaminated areas so as to rank areas for clearance. Analysis can also be carried out to identify tasks located near each other that may then be grouped together as a single task regardless of priority ranking, making both financial and logistical sense.

In the past, casualty and incident statistics were not properly recorded. Now, with a fully functional GIS, Landmine Action will record such information to ascertain possible hotspots for accidents. Three route assessments have been completed in the northern sector. As these routes have been ranked in order of threat level by Landmine Actionâ€™s Battle Area Clearance Technical Advisors and GIS Officers, more assessments must be carried out to ensure safer travel in Western Sahara for the local population, U.N. missions and aid agency vehicles.

Conclusion

Landmine Action has put GIS to good use in Western Sahara as both a mapping and a decision-support tool. The aim is to provide data in the simplest and most informative way possible for all stakeholders, including MINURSO, the Polisario Ministry of Defense, and organizations that work in Polisario-controlled regions. The benefits of GIS have proved immeasurable in the harsh conditions of Western Sahara when dealing with the often unseen threat that mines and ERW often pose to U.N., Polisario and Landmine Action staff members, as well as the local civilian population. GIS has proven a suitable tool for planning more efficient clearance and is consequently assisting in making Western Sahara a safer place.

Biography

Penelope Caswell has been the GIS Officer for Landmine Action since February 2008. She holds a Master of Science in geographical information systems and a bachelor's degree in environmental science and geographical information systems from the University of Nottingham, Nottingham, U.K., and the University of Greenwich, London, England, respectively. She is responsible for training national staff in global positioning systems and basic to advanced GIS skills, as well as for the effective collection and integration of GIS data.

Endnotes

1. U.N. Mission for the Referendum in Western Sahara (MINURSO). "Western Sahara: Updated Mine Situation." February 1998.
2. Western Sahara is unique because the majority of the population is based in the refugee camps in Algeria. Those communities based in Polisario-controlled Western Sahara are nomadic and don't settle in one location for very long, making it impossible to do an assessment of these communities. Hence, Landmine Action conducted a survey based purely on dangerous areas (minefields and cluster strike areas) and ERW contamination, which it termed a *Dangerous Area Survey*.

Reference

1. *Mine Action Lessons and Challenges*, Geneva International Centre for Humanitarian Demining, 37, section 9. November 2005. http://www.gichd.org/gichd-publications/mine-action-lessons-and-challenges/.

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